

central in northern Montana, and the LOW had advanced to southwestern Arizona.

On the 31st the HIGH was central over southeastern Montana, and the north end of the LOW had advanced up the coast to Vancouver Island, and seemed to be central in the Pacific Ocean just off the entrance to Grays Harbor. The isotherms on the weather map for that date show that the highest temperature in the western part of the United States was a spot about 70 miles in diameter on Grays Harbor. At Seattle the temperature jumped to 89°, and at Aberdeen to 93°; both abnormally high for western Washington. The prevailing winds were southeasterly, and in some localities were very strong. The relative humidity went to 21 per cent.

The fires which had been fanned into life during the preceding six days now became uncontrollable. One fire covered 25,000 acres, and destroyed more than half a million dollars' worth of property in an afternoon. This happened six days after a heavy rain had fallen, with all forest material soaked through and through. But these six days had been hot, windy, and dry. The moisture evaporated from the moss on the trees, the leaves and scaly bark; the feathery rotten wood on dead trees; the resinuous spills on the branches; the dead ferns and fireweed; all these became as tinder.

It is worth while to note that this HIGH rotated clockwise; that its nose first pointed southeast on the 27th, on the 29th it was a little to the southwest, on the 31st the elongation was southeast and northwest, on June 1 it had rolled northeasterly, and on June 5 had completely disappeared. It had occupied 10 days in passing—an unusually long time. Its strongest effects were felt when it was central over southeastern Montana and northeastern Wyoming.

At the time of the great Columbia fire, on September 12, 1902, the HIGH and the LOW occupied the same relative position to each other.

As soon as this HIGH disappeared, the weather conditions in western Washington immediately became normal; fires died down, were easy to control, and ceased to run.

Right here I want to emphasize the statement that the danger of a conflagration is just as great—and it as frequently occurs—in the spring of the year, when all forest material is damp and wet, as in the autumn following a dry summer. The rapid heating of the atmosphere in the spring as the sun advances north gives the air a greater capacity to absorb moisture than in the fall when it is cooling off.

All of the large fires in the Douglas fir region are caused by descending winds blowing outward from a HIGH.

In his discussion of the subject. Mr. Beals states "that in the case of the Michigan fires, and the Hinckley fire in Minnesota, the air currents were ascending and blowing inward toward a LOW."

I have not given this phase of the subject sufficient study to warrant me in making a statement as to why such a condition should cause great fires in one locality and not in another, but in passing I want to venture a guess on the matter, and that is, that it does not make any difference whether the wind is blowing from a HIGH or backing into a LOW—the effect is the same if it continues any length of time to come off a hot, arid land surface.

It would seem to me that the study of fire weather forecasts should include a close observation of what is taking place in Alaska and British Columbia, as there is where our trouble seems to develop. I will have to leave the question as to why the HIGH develops up there to the technician who understands that phase of meteorology. I am more concerned about where they go when they start wandering away from home.

From my own observation it would appear that an intensive study of the actions of these HIGHS by the United States Weather Bureau, supplemented and correlated with similar work done by our Canadian brothers, who are as vitally affected and interested in the subject as we are, would lead to a knowledge of the atmospheric disturbances which is the cause of all our trouble.

We need men versed in the technique of meteorology, who can give all of their time and attention to a study of the relationship of changes of weather as affecting forest fires. In order to render a maximum of help, they must, during critical periods of weather, be on the job night and day—Sundays and holidays included. They should be stationed in the danger zone where they can get first-hand knowledge of what occurs and the causes leading to it. Congress could not do anything more to assist reforestation and conserve the timber resources of the Douglas fir and white pine regions than to make the small appropriation asked for, which will enable the Weather Bureau to undertake this work.

The Weather Bureau has already done much to assist forest protective agencies. We fully appreciate what they are doing.

The fire hazard on the Pacific coast is growing worse; the potentialities of a catastrophic combination of weather and fire conditions which can bring disaster and ruin unprecedented are here. We are powerless to prevent the atmospheric forces from assembling and venting themselves in all their might, but we may gain a knowledge of their secrets and of the effect of their movements which will enable us to thwart their fury.

LIGHTNING AND FOREST FIRES IN CALIFORNIA.¹

By S. B. SNOW.

[United States Forest Service, September 17, 1923.]

Thunderstorms with accompanying lightning as a cause of forest fires have become of great importance during, roughly, the past 15 years, or since the national forests in California were put under administration. Foresters therefore are of necessity keenly interested in any contribution to our rather meager knowledge of this subject.

I propose to outline the nature of the problem as it affects the national forests, to point out what we are

doing in an effort to solve it, and what seem to be worthwhile lines for future study.

Lightning fires since 1911 have averaged about 440 per year, contributing over 41 per cent of the total fires from all causes. They are by long odds the most important single cause of fires. An analysis of 4,363 fires shows that they occur in extremely concentrated form: 89 per cent of all lightning fires are in June, July, and August; 77 per cent in July and August; and 44 per cent

¹ Presented at meeting of the American Meteorological Society at Los Angeles, Calif., Sept. 19, 1923.

in August alone. The seasonal distribution in the average case parallels the course of mean maximum temperatures, though fires tend to lag behind temperature.

This great seasonal concentration of fires, of course, tends to make suppression difficult, because so many fires occur at one time. The most striking evidence of the difficulty of successfully handling lightning fires is found in the fact that exceptional storms have set in a single day as many as 340 fires. I have classified storms into four general groups, those causing less than 50 fires, those with from 51 to 150 fires, those with from 151 to 250 fires, and those with over 250 fires. In handling fires resulting from storms of the first three classes we have been uniformly successful in holding the size of the average fire to about 35 acres, the figures for each class being 49, 29, and 34. In other words, though many fires result from these generally local storms, our protection organization is equipped to handle the situation.

For the three great general storms which have set over 250 fires, the situation is, however, radically different. Fires from these storms attained an average size of 312 acres, over eight times as great as from storms of the other classes. The largest fires known in northern California resulted from these catastrophes.

In practice, a general electrical storm, such as these, results in what may be regarded as an overload of business. We are not equipped to handle all fires promptly, and must rely on cooperative help, which is not always satisfactory. One of the most important contributions that could be made to organized fire protection in California, and, indeed, throughout the West, would be prediction, even a few hours in advance of the occurrence of these great general storms. We could then do much of the emergency organization work, which must now wait until fires are actually set.

Lightning fires individually are generally not particularly difficult to handle, but in bunches they represent perhaps the most severe test that fire protection forces must meet. During the past decade, on the average, 42 per cent of the entire crop of lightning fires for an entire season have occurred in a single storm, further evidence of the extreme concentration of this form of fire business.

I have spoken briefly of the when and how of lightning fires, and I should now like to speak of the where. We have plotted on a State map the point of origin of each fire for a period of 10 years. Even the most casual study shows that as a matter of recorded experience there are both well-marked lightning centers, and what may, I think, be fairly regarded as lightning zones. It seems evident:

1. That from north to south in the Coast Range, the belt generally decreases in width.
2. The same general trend is apparent in the Sierra Region.

3. In southern California the zones are generally narrower than elsewhere.

In intensity, or number of fires per unit of area, there is a general, though by no means regular, decrease from north to south.

This analysis of the place of occurrence of lightning fires has proved of great value in helping us to most effectively place our men, to organize detection service, etc. On the map there are many blank spots for which no explanation can now be offered. Whether they are purely accidental and will be filled in as more data accumulate is open to question. They may conceivably be out of the principal storm tracks.

This is the lightning fire zone in general. When we analyze the great storms, we find that they cover pretty much the same region. This is not true in detail, but the limit of southerly extension, for example, has been about the same for all three. The national forests to the south are subject to intense storms, but so far have not participated in the most extensive storms. This it seems is a point worthy of cooperative study.

This, then, is the situation in regard to lightning fires in the forests of California. Obviously enough, the greatest contribution to better handling of them would be the ability to predict the occurrence, particularly of the great general storms. It is probably true that these storms are intimately related to the general weather condition and can be predicted, given sufficient study of the problem. The more local convectional storms are also worthy of attention. Undoubtedly lightning storm centers exist, where storms form repeatedly and from which they travel. One such center is certainly the Sierra Valley, another is the region around Mount Shasta.

For three years now the Forest Service has been utilizing its fire lookout men as recorders of the occurrence and movements of storms. Hundreds of observations have been made, and an analysis of this mass of data will doubtless prove of value. If it is found that storms forming in a particular center tend to travel in a given direction, it will be possible to phone ahead of the storm, and thus to make predictions at least a few hours in advance. Similar data have been secured for the past two seasons in Idaho, Montana, Washington, and Oregon, as well as in California, and suggestive leads for further investigation have already been uncovered.

More study, I believe, is needed of the occurrence of lightning storms in relation to general weather conditions. Cooperative study of this phase of the problem should certainly be of value. In general, the securing of field data is probably the most serious difficulty to be overcome in realizing our goal of prediction of lightning storms. It seems to me not beyond the possible that the field men of the Forest Service, particularly our lookouts, may prove to be ideally situated for that purpose.

HOW WEATHER FORECASTING CAN AID IN FOREST FIRE CONTROL.¹

By HOWARD R. FLINT.

The title subject given above is one so little discussed by those most concerned that one might almost be led to believe that it had been forbidden by a perpetuation of the drastic forest laws of the time of the Norman Conquest or by the merry days of Robin Hood, when an eye or a right forefinger and thumb of the skilled but unhappy archer was the price paid for a minor transgression of the laws of the king's forest. Of course no such taboo has actually existed, but natural conserva-

tism and inertia have ever been about as effective as written legislation in retarding inevitable progress. The result has been a failure on the part of the average forester to make full use of a tool which may be of great use to him.

Ten years ago the average forester would probably have dismissed the subject with the ironic remark that anyone could tell when he was going to have a fire by the absence of rainfall for a fortnight, and that knowing

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